

## **AMENDMENTS TO THE CLAIMS:**

### **Complete Listing of Claims**

- 1 Claim 1. (previously presented) A microcontroller integrated circuit (IC)  
2 comprising:  
3 a program memory for storing a program to be executed;  
4 a program counter coupled to the program memory for selecting address  
5 locations in said memory;  
6 a program counter copy register for storing a program memory address  
7 pointed to by said program counter as a return address from a debug monitor  
8 routine;  
9 instruction execution circuitry coupled to the program memory for  
10 executing instructions received from said memory;  
11 a breakpoint address register for storing a breakpoint address;  
12 address compare circuitry for comparing a value in said program counter  
13 to a value in said breakpoint address register, said compare circuitry providing a  
14 breakpoint signal upon detection of a valid breakpoint address comparison; and  
15 a multiplexer interposed between said program memory and said program  
16 execution circuitry, said multiplexer comprising circuitry for inserting a debug  
17 instruction into the instruction execution circuitry upon receipt of said breakpoint  
18 signal, wherein said debug instruction is substituted for an instruction in a  
19 program memory address pointed to by said program counter.

1 Claim 2. (original) The microcontroller IC of claim 1, further comprising:  
2 a stack pointer register;  
3 a stack breakpoint register for storing a stack trap address;  
4 stack pointer compare circuitry for comparing a value in said stack pointer  
5 register to a value in said stack breakpoint register, said stack pointer compare  
6 circuitry providing a stack trap signal upon detection of a valid stack pointer  
7 address comparison; and  
8 wherein said multiplexer inserts said debug instruction into the instruction  
9 execution circuitry upon receipt of said stack trap signal.

1 Claim 3. (original) The microcontroller IC of claim 2, wherein said valid stack  
2 pointer address comparison is selected from the group consisting of: said value  
3 in said stack pointer register being equal to said value in said stack breakpoint  
4 register, said value in said stack pointer register being greater than said value in  
5 said stack breakpoint register, said value in said stack pointer register being less  
6 than said value in said stack breakpoint register, and combinations thereof.

1 Claim 4. (original) The microcontroller IC of claim 1, further comprising single  
2 step circuitry directing said multiplexer circuitry to insert said debug instruction  
3 into the instruction execution circuitry after the execution of each instruction of an  
4 application program.

1 Claim 5. (original) The microcontroller IC of claim 1, wherein said debug  
2 instruction is a long jump instruction to a debug monitor routine.

Claim 6 (canceled)

1 Claim 7. (original) The microcontroller IC of claim 1, wherein said address  
2 comparison circuitry further comprises memory bank comparison circuitry for  
3 detecting a specific bank access in addition to said breakpoint address.

1 Claim 8. (previously presented) An embedded microcontroller apparatus  
2 comprising:

3 a circuit board embedded in the apparatus;

4 a microcontroller integrated circuit disposed on said circuit board,

5 including

6 a program memory for storing a program to be executed,

7 a program counter coupled to the program memory for selecting address  
8 locations in said memory,

9 a program counter copy register for storing a program memory address  
10 pointed to by said program counter as a return address from a debug monitor  
11 routine, and

12 debug circuitry disposed on said microcontroller integrated circuit, said  
13 debug circuitry comprising

14 compare circuitry for comparing a breakpoint address to instruction

15 fetch addresses in said program memory, said compare circuitry

16 generating a breakpoint signal indicating a valid address compare; and

17 multiplexer circuitry coupled to said compare circuitry, said

18 multiplexer circuitry, upon receiving said breakpoint signal, substituting a

19 debug program instruction for execution by the microcontroller in place of

20 a standard instruction fetched from program memory.

1 Claim 9. (original) The embedded microcontroller apparatus of claim 8,  
2 wherein said apparatus is a universal serial bus controller.

1 Claim 10. (original) The embedded microcontroller apparatus of claim 8,  
2 wherein said microcontroller further comprises a stack pointer register, and said  
3 debug circuitry further comprises:  
4 a stack breakpoint register for storing a stack trap address; and  
5 stack pointer compare circuitry for comparing a value in said stack pointer  
6 register to a value in said stack breakpoint register, said stack pointer compare  
7 circuitry providing a stack trap signal upon detection of a valid stack pointer  
8 address comparison; wherein said multiplexer substitutes said debug program  
9 instruction for execution by said microcontroller upon receiving said stack trap  
10 signal.

1 Claim 11. (original) The embedded microcontroller apparatus of claim 10,  
2 wherein said valid stack pointer address comparison is selected from the group  
3 consisting of: said value in said stack pointer register being equal to said value in  
4 said stack breakpoint register, said value in said stack pointer register being  
5 greater than said value in said stack breakpoint register, said value in said stack  
6 pointer register being less than said value in said stack breakpoint register, and  
7 combinations thereof.

1 Claim 12. (original) The embedded microcontroller apparatus of claim 8, said  
2 debug circuitry further comprising single step circuitry directing said multiplexer  
3 circuitry to substitute said debug program instruction for execution by said  
4 microcontroller after the execution of each standard instruction fetched from  
5 program memory.

1 Claim 13. (original) The embedded microcontroller apparatus of claim 8,  
2 wherein said debug program instruction is a long jump instruction to a debug  
3 monitor routine.

Claim 14 (canceled)

1 Claim 15. (previously presented) A method of debugging a microcontroller  
2 integrated circuit, said method comprising:  
3 storing a breakpoint address in a hardware register on said microcontroller  
4 integrated circuit;  
5 executing an application program from program memory by said  
6 microcontroller;  
7 comparing application program instruction addresses to said breakpoint  
8 address;  
9 halting execution of said application program upon detection of an  
10 instruction fetch from a memory address equal to said breakpoint address;  
11 storing said memory address in a program counter copy register, wherein  
12 said address is reloaded into said program counter after execution of said debug  
13 routine;  
14 substituting a jump instruction to a debug program for said instruction  
15 fetched from said memory address; and  
16 executing said debug program.

1 Claim 16. (original) The method of claim 15, further comprising:  
2 storing a stack trap address in a stack breakpoint hardware register on  
3 said microcontroller;  
4 comparing stack pointer addresses to said stack breakpoint address; and  
5 upon detection of a valid stack pointer address comparison, performing  
6 said halting execution, said substituting said jump instruction, and said executing  
7 said debug program steps.

1 Claim 17. (original) The method of claim 16, wherein said valid stack pointer  
2 address comparison is selected from the group consisting of: said stack pointer  
3 address being equal to said stack breakpoint address, said stack pointer address  
4 being greater than said stack breakpoint address, said stack pointer address  
5 being less than said stack breakpoint address, and combinations thereof.

1 Claim 18. (original) The method of claim 15, said executing said debug program  
2 comprising:  
3 providing status information to external circuitry; and  
4 receiving new breakpoint address information.

Claim 19 (canceled)

1 Claim 20. (previously presented) The method of claim 15, further comprising  
2 pushing the address stored in the program counter copy register onto a stack  
3 and executing a return to said application program at a location pointed to by  
4 said memory address.